EVALUATING CONSTRUCTION ACTIVITIES IMPACTING ON WATER RESOURCES: PART II

GUIDELINES FOR CONSTRUCTION OF HIGHWAYS AND BRIDGES

March, 1984

Environment
Environnement

EVALUATING CONSTRUCTION ACTIVITIES IMPACTING ON WATER RESOURCES: PART II

GUIDELINES

FOR

CONSTRUCTION OF

HIGHWAYS AND BRIDGES

March, 1984

Prepared by:

D.A. Boyd and D. Persaud
Great Lakes Section
Water Resources Branch

CONTENTS

FOREWORD

In 1976 the Ontario Ministry of the Environment (MOE) published the handbook Evaluating Construction Activities Impacting on Water Resources to be used in the assessment of the environmental impacts of construction activities. At that time it was indicated that the handbook would be revised as further information was accumulated, and the considerable experience gained since 1976 now warrants such a revision in order to better reflect current knowledge. These guidelines for the construction of highways and bridges form the second of five parts in an updated set of handbooks designed to replace the 1976 handbook. The other parts, each to be published as a separate volume, deal with the construction of pipelines crossing watercourses (Part I 1983); dredging and spoils disposal (Part III 1984); marine construction (Part IV 1983); and small scale construction projects (Part V 1983);.

Most highway and bridge projects in the Province of Ontario are undertaken by the public sector and are, therefore, subject to the Environmental Assessment Act. Proponents of such projects are required to prepare an Environmental Assessment (EA) for review by concerned agencies prior to a decision by the Minister of the Environment regarding approval. From a water resources perspective, good construction practice requires that every effort be made to preserve the physical and biological integrity of Ontario's waterbodies in accordance with Provincial goals to preserve and enhance ground and surface water quality and quantity (Ontario Ministry of the Environment 1978).

This document has been compiled to aid proponents and reviewers by providing a basic information package of water resources concerns for use in the impact assessment process. The aim is to provide assistance in both anticipating potential impacts and in planning adequate mitigative measures. Clearly, the type and scale of each project, in conjunction with site specific conditions, will determine which of the wide range of potential impacts will require specific attention. Similarly, the technical aspects of mitigative measures (and associated monitoring) will vary according to individual project circumstances.

Accordingly, the first chapter presents a general range of potential adverse impacts on the water environment associated with highway and bridge construction projects and is followed by a chapter containing general recommendations for their mitigation. The final chapter provides suggestions for meeting water resources content requirements during EA preparation as a means of streamlining the review process.

Although it is not possible to document every potential problem associated with highway and bridge projects in a handbook such as this, it is hoped that most major concerns have been covered. The key to successful application of the recommendations outlined in this handbook is a precise understanding of their rationale on the part of the proponent and its contractor(s). Proponents are encouraged to consult with local MOE offices early in the planning and design process so that potential concerns are raised at a stage when they can be most readily addressed.

I POTENTIAL IMPACTS OF HIGHWAY AND BRIDGE CONSTRUCTION PROJECTS ON THE WATER ENVIRONMENT

1. INTRODUCTION

The construction of highway and bridge projects results in a range of effects upon the water environment (i.e. physical and chemical changes in the stream system) which can be evaluated and expressed as an impact (i.e. the result of the effect on the stream biota and other beneficial uses). This distinction between an effect and an impact can be illustrated by the case when introduction of construction related sediment into a watercourse occurs. One effect of this activity is the temporary creation of turbid water. This effect may result in an adverse impact on fish.

Depending on site specific conditions and the type of project, any of a wide range of effects may occur creating the potential for adverse impacts of varying magnitude. In general, impacts on water resources can be described as short-term or long-term, depending on whether they are associated with the construction, or post-construction phase of a project.

The initial sections of this chapter outline various short-term and long-term effects on the physical/chemical water environment which may occur due to highway and bridge construction and operation. This is followed by a discussion of the resulting potential impacts upon aquatic biota, and other beneficial uses.

2. SHORT-TERM EFFECTS ON THE ABIOTIC WATER ENVIRONMENT

Effects related to the construction phase are the most easily observed and frequently can be directly attributed to specific activities. The most common effects are summarized below.

2.1 Erosion and Sedimentation

The major impact on the water environment associated with the construction phase is the input of sediment as a result of increased land surface erosion. The absence of protective vegetative cover during clearing, grading, blasting and trenching operations, combined with the continual movement of heavy equipment decreases the infiltration capacity of the soil and renders the surface highly susceptible to erosion by surface runoff. As a result construction has been demonstrated to yield the highest erosion rates of any land use activity (Canter 1977).

Once eroded material has been washed into a watercourse it may, depending on the particle size and watercourse flow, settle to form a bed deposit, or become entrained as bedload and/or suspended load. In most cases a combination of the three occurs.

2.2 Degradation of Ground and Surface Water Quality

The most direct cause of surface water quality degradation is in or near stream construction activity. However, water quality within and adjacent to construction sites will also be affected by the input of various pollutants (e.g. metals, oil and grease, asphalts, calcium chloride, etc. from construction machinery, access roads, etc.) via surface runoff. Once in the watercourse suspended particles increase turbidity and provide a medium for the transport of adsorbed contaminants.

Depending upon the drainage characteristics of the site and surrounding area, pollutants may be transported considerable distances and water quality may be impaired at points well removed from the original site.

Ground water quality may also be affected temporarily due to infiltration of contaminated surface water.

2.3 Disruption of Ground and Surface Water Quantity

Such activities as the dewatering of trenches, cut and fill operations, blasting, and the reduction of infiltration due to surface compaction, can disrupt the pattern of ground and surface water flow by altering ground water levels.

Flow diversion for instream work may substantially alter the pattern of streamflow and result in such negative effects as increased scour (in-channel erosion) within the diversion, increased sedimentation downstream, or cessation of flow during low flow periods.

2.4 Damage to Watercourse Bed and Banks

Blasting operations and the operation of heavy equipment on the bed and banks of watercourses can cause significant changes in channel morphology. This will alter the watercourse flow pattern, and may result in effects such as scour, increased concentrations of suspended solids, and blanketing of the channel bed.

3. LONG-TERM EFFECTS ON THE ABIOTIC WATER ENVIRONMENT

Effects occurring during the post-construction phase of a project are much more difficult to predict and explain. Such effects tend to be indirect and may occur gradually over a prolonged period. The most obvious effects are summarized below.

3.1 Channel Modification

Channel modification is frequently necessitated in those cases where projects cross or infringe on a watercourse (i.e. protection from overbank flows and stabilization of banks). This is usually achieved by some combination of: straightening, widening, deepening, clearing, lining, bank reconstruction, modification of grade, rerouting of existing drainageways, and construction of artificial drainage systems.

Natural watercourses represent a "quasi-equilibrium" of sediment and water inputs and outputs. Since channel modification has the potential to disrupt this equilibrium, resulting in both local and basin wide effects, it is of fundamental importance that adequate consideration be given to potentially adverse environmental effects.

Alteration of a watercourse regime may occur as the result of local changes in bed/bank morphology and composition (i.e. altered depth, width, gradient, size of bed material). Morphological changes often result in altered flow patterns which disrupt the local scour and fill (short-term, in-channel erosion and deposition) equilibrium. The interdependent nature of channel morphology, watercourse flow patterns, and bed material composition can, therefore, result in the migration of local changes up and down the stream system.

3.2 Increased Surface Runoff

Highway and bridge construction results in the replacement of "natural" surfaces by highly impervious paved surfaces. This will reduce infiltration, lag time, and subsurface flow, while the total

volume of runoff increases (i.e. greater volumes of water will flow over the surface at higher velocities reaching a watercourse in less time compared to preconstruction conditions). In general, post-construction peak flows tend to be increased and base flows tend to be reduced. The most significant consequence of this altered range of discharges is increased channel activity. Guy (1970) has noted that while erosion of the land surface is the major problem during construction, channel erosion predominates during the subsequent stabilization period.

3.3 Degradation of Surface Water Quality

Water quality can be impaired as a result of any reduced ground water component of stream flow and a corresponding increase in the contribution of surface runoff. Reduced low flows mean that the assimilative and flushing capacity of a stream is reduced, while the increased surface runoff will transport contaminants (e.g. oil and grease, deicing compounds, etc.) directly into the watercourse without the benefit of subsurface filtering (i.e. under natural conditions contaminants may be adsorbed and particulates retained during infiltration).

3.4 Disruption of Ground Water Quality and Quantity

A completed project has the potential to alter ground water conditions, locally and regionally, by changing the slope and soil composition of an area and hence the gravitational and capillary forces which govern subsurface flow. Outflows from excavations can result in the permanent lowering of ground water levels. The quality of ground water can be impaired by the percolation of contaminated surface runoff down to aquifers.

4. POTENTIAL IMPACTS ON AQUATIC BIOTA

Potential impacts on aquatic biota may result from both short and long term effects on the water environment. Interference with any part of the stream ecosystem structure has the potential to adversely affect the entire system.

For the purposes of the following discussion the complex and inter-related components of the ecosystem have been classified as primary productivity, benthic organisms, and fish.

4.1 Primary Productivity

The photosynthetic production of organic matter by the lower members of the aquatic food web (autotrophs) is referred to as primary productivity. It may be adversely affected by short-term increases in levels of suspended solids and associated contaminants, first as a result of light attenuation, and second as the result of direct exposure to toxic substances.

Long term impacts usually relate to modification of channel morphology, flow characteristics, and bed material composition. The increased peak flows, reduced base flows, and loss of in-channel morphological variation (i.e. pools and riffles) which accompany stream modification may preclude recolonization by species present before construction. Since primary productivity represents a nutrient source for other components of the stream ecosystem this impact may be far reaching.

4.2 Benthic Organisms

The survival of benthic organisms depends upon the preservation of the watercourse substrate as suitable habitat. The blanketing of the channel bed with contaminated sediment which may accompany near-stream construction activity, and the damage which results from in-stream work, both act as severe stresses to the benthic community. Organisms may either be destroyed (i.e. smothered or exposed to toxic compounds) or they may drift downstream (Hynes

1973) and since they form a vital link in the aquatic food chain dependent predators will be forced to abandon any regions thus affected.

Long term impacts can also be expected to occur as the result of alterations to the watercourse regime (i.e. increased peak flows, reduced base flows, channel modification effects). The disruption of the pre-construction scour and fill equilibrium, loss of in-channel morphological variation, and changes in bed material composition will all result in loss of suitable habitat.

In addition, the removal of riparian vegetation (which frequently accompanies channelization) will reduce the amount of leaf litter which enters the system. Since, in small streams, this represents the major source of organic matter utilized by the stream community (Cummins and Spengler 1978), benthic organisms may also encounter a critical nutrient shortage.

4.3 Fish

The increased turbidity and impaired water quality associated with the construction phase of projects will adversely affect local fish populations, while in-stream work will have the additional effect of impeding migratory passage.

Fish which rely on sight for feeding and the detection of predators will experience a reduction in their reactive distance as a result of high turbidity levels (Illinois EPA 1979). High suspended sediment concentrations may also disrupt the respiratory mechanism of fish through clogging or abrasion of the gills. Although many species of adult fish are able to withstand this, by exuding a protective mucous, their survival is still jeopardized by the associated depletion of metabolic reserves at a time when turbidity inhibits the detection of food (Illinois EPA 1979).

Sediment accumulation in spawning areas can also affect the hatching of eggs by clogging substrate interstices thereby interfering with the normal exchange of water which replenishes the oxygen supply and removes accumulated wastes. It may also pose a physical obstruction to emerging fry.

The loss of reproductive capacity through physiological stress, loss of spawning beds, and destruction of fry may result in a more significant impact than short-term abrasion and clogging (Illinois EPA 1979).

Long-term disruption of pre-construction habitat may occur in several ways. For example, the removal of riparian vegetation causes a loss of shade which can increase the magnitude of water temperature fluctuations thereby affecting dissolved oxygen levels and eliminating the cold water fishery potential of certain streams. The loss of in-channel shelter, long-term damage to spawning beds, decreased low flows, and impaired water quality may also have a severe impact on fish populations.

In addition to these direct impacts, the loss of food resulting from impacts on primary productivity and benthic organisms will also tend to inhibit post-construction re-colonization by former species.

5. POTENTIAL IMPACTS ON OTHER BENEFICIAL USES

In addition to causing negative impacts on the watercourse ecosystem, the short and long term effects of construction projects can have other adverse impacts. These are summarized below.

5.1 Impaired Water Supply

Short-term impacts on recreational and drinking water supplies may occur as the result of construction related increases in turbidity and contaminant levels, or disruption of ground or surface water flow.

Long-term impacts will relate to post-construction effects on the quality and quantity of ground and surface water. Contamination and disruption of ground and surface water supplies will adversely affect water users, both local and regional.

5.2 Flow Obstruction and Increased Downstream Flood Hazard

Flow obstruction frequently results from construction related accumulations of sediment and debris. The increased peak flows associated with the post-construction phase of the project will result in an increased downstream flood risk which may be exacerbated by residual flow obstructions.

5.3 Structural Damage

Construction related damage to watercourse banks (e.g. operation of heavy equipment, removal of vegetation, subsidence from dewatering) can increase their susceptibility to subsequent erosional damage and slumping, as can the increased channel activity associated with alterations in the local hydrological regime. This may endanger such nearby structures as buildings and roads, and can lead to the failure of in-channel structures such as bridges and culverts.

5.4 Impaired Recreation

Both construction and post-construction effects have the potential to disrupt downstream recreation. Direct use of a watercourse for activities such as swimming or fishing will be curtailed by the short-term effects on water quality (see Section 2) and by loss of access. Indirect uses such as adjacent parks and trails will suffer from such long-term effects as the loss of aesthetic value due to depleted low flows, bank failures, and the installation of unsightly stabilization measures (e.g. gabion baskets, concrete channel).

II RECOMMENDATIONS FOR HIGHWAY AND BRIDGE CONSTRUCTION

1. INTRODUCTION

The construction of highways and bridges has the potential for a wide range of impacts on the water environment (as outlined in Chapter I). The potential significance of this type of project is illustrated by the fact that construction of a typical four-lane highway exposes roughly 50 x 10^3 m^2 of ground per kilometre (20 acres per mile), of which approximately half is eventually covered by the paved surface and shoulders (Wolman and Schick 1967).

Chapter II briefly outlines various highway and bridge construction operations as a means of classifying a list of recommendations for construction of highways and bridges with minimal short and long-term impacts on the water environment.

2. OVERVIEW OF HIGHWAY AND BRIDGE CONSTRUCTION OPERATIONS

Details of construction operations will depend upon the size of the project, site specific conditions, and the contractor. For the purposes of these guidelines, however, a series of general, interdependent operations have been summarized below.

GENERAL SUMMARY OF HIGHWAY AND BRIDGE CONSTRUCTION OPERATIONS

OPERATION	DESCRIPTION
Clearing and Grubbing	A variety of equipment is used to remove trees and stumps, and other vegetation from the right-of-way (RoW).
Grading	Heavy equipment and/or explosives are used to "cut" and "fill" original topography to the grades specified in contract drawings. "Borrow" material may be required in some cases, while in others disposal of surplus material may be necessary.
Drainage	Excavation of temporary and permanent drainage ditches and stream diversions is undertaken, and culverts and storm sewers are installed.
Preparation of the Road Bed	Heavy equipment is used to compact the surface, and a layer of granular material is installed.
Surfacing	Concrete and/or asphalt paving is installed.
Bridges	Embankments are constructed, foundations are installed and footings, abutments and piers are constructed to support the superstructure and deck.

3. RECOMMENDATIONS

Generally speaking, the mitigation of construction-related impacts can be achieved through a combination of good construction practices and various site specific "control" methods. Mitigation of long-term impacts, on the other hand, is usually best addressed through a combination of careful project design and site restoration.

3.1 Mitigation of Potential Short-Term Impacts

The following recommendations for mitigation of construction-related impacts are presented according to the general sequence of operations as indicated previously.

3.1.1 Clearing and Grubbing

(1) VEGETATIVE COVER SHOULD BE PRESERVED FOR AS LONG AS POSSIBLE.

Soil can be protected against erosion by preserving easily removed ground cover (e.g. brush, shrubs, etc.) until grading operations are ready to commence.

(2) ALL ACCUMULATED DEBRIS AND SOIL RESULTING FROM CLEARING AND GRUBBING SHOULD BE LOCATED AWAY FROM WATERCOURSES AND TEMPORARILY STORED OR DISPOSED OF IN A MANNER ACCEPTABLE TO ADJACENT PROPERTY OWNERS AND/OR RELEVANT GOVERNMENT AGENCIES (e.g. Ontario Ministry of the Environment (MOE), Ontario Ministry of Natural Resources (MNR), local Conservation Authority).

Locating stockpiles of cleared material away from watercourses will prevent the degradation of water quality by sediment and organic debris. Permission of property owners and government agencies regarding method and location for disposal of such material will ensure adequate consideration of site specific concerns.

(3) REMOVAL OF RIPARIAN VEGETATON SHOULD BE MINIMIZED.

Riparian vegetation provides a buffer between areas under construction and watercourses which can help protect against degradation of water quality by contaminated runoff (i.e. through filtration of overland flow). It also forms a valuable nutrient and habitat component of the stream ecosystem.

(4) IN REGIONS WHERE POTENTIAL IMPACTS ON FISHERIES EXIST, CONTACT SHOULD BE MADE WITH APPROPRIATE GOVERNMENT AGENCIES (e.g. MOE, MNR) PRIOR TO THE COMMENCEMENT OF ANY CONSTRUCTION ACTIVITY.

The fishery potential of a stream will play a fundamental role in determining construction techniques and timing as well as the design of instream structures. For this reason, contact should be made with MOE and MNR early in the planning and design stage.

3.1.2 Grading

(1) NEWLY GRADED SLOPES SHOULD HAVE ADEQUATE EROSION CONTROL MEASURES INSTALLED AS SOON AS POSSIBLE (e.g. berms, rip-rap, aggregate cover, seeding mulching, sodding, vegetation plugs, etc.).

Any recently excavated or filled area will be highly susceptible to erosion until it is stabilized. Wherever possible stabilization should be part of the grading operation.

(2) BLASTING SHOULD BE UNDERTAKEN IN A MANNER DESIGNED TO MINIMIZE WATER QUALITY AND QUANTITY IMPACTS ON LOCAL WELLS AND WATERCOURSES. MONITORING OF POTENTIALLY AFFECTED WELLS SHOULD BEGIN PRIOR TO BLASTING.

A careful estimation of the potential impacts on local wells and streamflow incorporating all necessary hydrogeological and water quality data should accompany all proposals to excavate by means of blasting. Suitable precautions can then be taken to prevent damage to channel morphology and subsurface soil structure.

3.1.3 Drainage

(1) THE CONSTRUCTION OF ALL TEMPORARY AND PERMANENT DRAINAGE DITCHES, CULVERTS AND SEWERS SHOULD BE COMPLETED AS RAPIDLY AS POSSIBLE. THESE ACTIVITIES SHOULD INCORPORATE EROSION AND SEDIMENT CONTROL MEASURES SUFFICIENT TO ENSURE THAT OFF SITE IMPACTS ARE MINIMIZED.

Local and downstream impacts on surface water can be minimized by planning construction schedules so that all the necessary materials and equipment to complete the job are on site prior to excavation, and by ensuring that the installation of erosion and sediment control measures is incorporated into the construction process. Rapid completion and restoration of temporary drainageways will also help minimize disruptions of ground water flow resulting from "french drain" effects (i.e. diversion of ground water flow).

(2) DEWATERING OPERATIONS SHOULD INCORPORATE MEASURES TO MINIMIZE IMPACTS ON GROUND AND SURFACE WATER USERS. OUTFALLS SHOULD BE LOCATED AND PROTECTED SO AS TO PREVENT ANY EROSIONAL DAMAGE (e.g. gravel or grass "splash pad"). ALL WATER USERS WHOSE SUPPLIES ARE INTERRUPTED SHALL BE PROVIDED AN ALTERNATE SOURCE (as outlined in the Ontario Water Resources Act).

The impact of any temporary disruption in ground and surface water supply by construction related dewatering operations can be reduced through (a) advance notification of potentially affected users and provision of alternate supply where needed, (b) rapid completion of activities, and (c) the application of effective erosion control at outfalls. Extraction of more than 50 m^3 per day will require a "Permit To Take Water" from MOE.

(3) THE CONSTRUCTION OF ANY NEW DRAINAGEWAY SHOULD BE UNDERTAKEN BY MEANS OF DRY CONSTRUCTION. THE NEW CHANNEL SHOULD BE COMPLETED AND ADEQUATELY ARMOURED WHEREVER NECESSARY PRIOR TO THE DIVERSION OF FLOW FROM EXISTING DRAINAGE NETWORK.

Channel excavation not utilizing dry construction can result in massive sedimentation, slumping of banks, and other related impacts.

3.1.4 Preparation of the Road Bed

(1) ANY RUNOFF FROM AREAS BEING COMPACTED SHOULD BE PREVENTED FROM DIRECTLY ENTERING WATERCOURSES.

Surface compaction reduces soil infiltration capacity and encourages sediment laden overland flow. This will require the application of adequate sediment control measures (e.g. impoundment, filtering) in order to minimize the input of sediment into watercourses.

3.1.5 Surfacing

(1) PRECAUTIONS SHOULD BE TAKEN TO ENSURE THAT PAVEMENT CONSTRUCTION DOES NOT RESULT IN WATERCOURSE CONTAMINATION BY SUCH MATERIALS AS LIME, CEMENT, OIL AND GREASE, ASPHALT, ETC.

Contaminated runoff can result in significant local and downstream impacts and should, therefore, be restricted from direct entry into watercourses.

3.1.6 Bridges

(1) THE APPROPRIATE AGENCIES (e.g. MOE, MNR, Conservation Authority) SHOULD BE CONTACTED TO ENSURE THAT ALL INSTREAM AND NEARSTREAM ACTIVITY IS PLANNED AND CARRIED OUT SO AS TO CAUSE MINIMAL DISTURBANCE TO FISH, RECREATION, AND ANY OTHER LOCAL USES.

Depending upon the site specific circumstances a variety of concerns will necessitate such "good housekeeping" precautions as: acceptable disposal and stabilization of excavated,

erodible material; use of protective dykes or cofferdams; maintenance of adeqate channel capacity; erosion protection; bank stabilization; and designation of acceptable refuelling areas.

(2) INSTREAM AND NEARSTREAM WORK SHOULD BE COMPLETED AS RAPIDLY AS POSSIBLE DURING THE LOW STREAMFLOW PERIOD.

Once such activity commences it is important that it be rapidly completed so as to confine the unavoidable adverse impacts on the watercourse to the season (usually summer) when the least amount of damage is likely to result.

(3) THE USE OF HEAVY EQUIPMENT ON STREAM BED OR BANKS SHOULD BE KEPT TO A MINIMUM. WHERE REPEATED CROSSINGS ARE REQUIRED THESE SHOULD BE CONFINED TO ONE LOCATION AND SHOULD EMPLOY AN ARMOURED FORD OR TEMPORARY BRIDGING.

Every effort should be made to prevent damage to watercourse bed and banks. This will reduce short-term impacts <u>and</u> simplify post-construction restoration.

(4) ALL NEAR-CHANNEL GRADING OPERATIONS (e.g. embankment construction) SHOULD INCORPORATE IMMEDIATE EROSION PROTECTION AND STABILIZATION.

Any fill deposited and graded adjacent to a watercourse has the potential to result in the input of large quantities of sediment. Every precaution should be taken to ensure that this does not occur.

3.1.7 Monitoring and Maintenance

(1) ALL MITIGATIVE MEASURES SHOULD BE MONITORED REGULARLY TO ENSURE CONTINUED EFFECTIVENESS AND ALL NECESSARY MAINTENANCE SHOULD BE UNDERTAKEN IMMEDIATELY. RESULTS OF MONITORING SHOULD BE AVAILABLE FOR REVIEW BY MOE AND/OR OTHER CONCERNED AGENCIES.

The installation of various mitigative measures cannot be expected to provide adequate protection unless complemented by regular inspection and maintenance by the proponent. Contingency measures should be available in case of sub-standard performance or failure of existing measures.

3.2 Mitigation of Potential Long-Term Impacts

The simplest and most effective means of minimizing long-term impacts is through careful consideration of potential impacts at the planning and design stage and through detailed attention to site restoration. The following recommendations represent general design and site restoration considerations for various aspects of highway and bridge construction.

3.2.1 Alignment

(1) WHERE FEASIBLE, RIGHT OF WAY ALIGNMENT SHOULD MINIMIZE THE NUMBER OF WATERCOURSE CROSSINGS AND MAXIMIZE THE DISTANCE FROM ACTIVE WELLS OR OTHER WATER USES.

The most effective way to minimize impacts on ground and surface water use is to avoid them altogether. The fewer the number of watercourse crossings and the greater the separation between the right of way, wells and other uses, the smaller the resulting impacts will usually be.

3.2.2 Grade

(1) DISRUPTION OF SUBSURFACE FLOW SHOULD BE MINIMIZED THROUGH THE USE OF APPROPRIATE FILL MATERIAL.

Although a certain amount of subsurface flow alteration is inevitable when changes in local topography and composition of surface material are made, this can be reduced through the selection of fill material which will minimize such alterations (e.g. creation of impermeable barriers, or "french drain" effects).

3.2.3 Drainage

(1) WATERCOURSE RECHANNELLING (i.e. permanent flow diversion) SHOULD BE AVOIDED WHEREVER POSSIBLE.

The rechannelling of a watercourse exemplifies extreme disruption of the natural system and its equilibrium and can result in severe post-construction impacts over a stabilization period of several years.

(2) ALL PERMANENT DIVERSION CHANNELS SHOULD BE PROTECTED, AND SHOULD INCORPORATE SUFFICIENT ENERGY DISSIPATION MEASURES AND/OR DOWNSTREAM EROSION PROTECTION TO PREVENT SCOUR AT (OR DOWNSTREAM FROM) THE POINTS OF CONFLUENCE WITH THE OLD CHANNEL.

If the project cannot avoid the need for permanent flow diversions the severity of the various impacts can be reduced through careful design.

(3) PERMANENT DRAINAGE DITCHES SHOULD BE DESIGNED TO MINIMIZE IMPACTS ON EXISTING WATERCOURSES AND GROUND WATER BY AVOIDING LARGE CUTS, INCORPORATING PROTECTION AGAINST SCOUR, AND AVOIDING UNPROTECTED DISCHARGES INTO NATURAL WATERCOURSES.

Water quality in ditches collecting surface runoff will be low. As a result it will be necessary to estimate whether local ground water resources require protection from contamination through infiltration of such water, or whether local surface water quality protection requires that it be prevented from directly entering natural water courses.

(4) CULVERT DESIGN SHOULD ENSURE MINIMAL UPSTREAM AND DOWNSTREAM EFFECTS BY INCORPORATING ADEQUATE INLET AND OUTLET EROSION PROTECTION WHEREVER NECESSARY, AND ENERGY DISSIPATION MEASURES TO PREVENT INCREASED DOWNSTREAM VELOCITIES. THE INVERT ELEVATION SHOULD PROVIDE A SUFFICIENT DEPTH OF WATER FOR THE PASSAGE OF FISH AT LOW FLOWS WHILE AVOIDING BACKWATER EFFECTS AT PEAK FLOWS. THE CULVERT DIAMETER SHOULD BE SIZED TO ACCOMMODATE ANTICIPATED DISCHARGE FLUCTUATIONS, INCLUDING THOSE RESULTING FROM ICE DAMMING OR OTHER BLOCKAGES.

Improperly sized and installed culverts can cause numerous post-construction impacts including nuisance conditions (e.g. stagnant ponding), structural damage (e.g. washing out of embankments), and disruption of habitat for aquatic organisms (e.g. barrier to fish migration).

3.2.4 Bridges

(1) BRIDGE DESIGN SHOULD MINIMIZE THE USE OF INSTREAM AND NEARSTREAM SUBSTRUCTURES AND SHOULD MEET THE APPROVAL OF ALL APPROPRIATE GOVERNMENT AGENCIES (e.g. MOE, MNR, Conservation Authority).

The extent of channel modifications, and hence potential impacts, can be reduced by locating structures as far from the watercourse as possible.

(2) CHANNEL MODIFICATION SHOULD CAUSE MINIMAL FLOW ALTERATION, INCORPORATE MEASURES FOR THE PROTECTION OF STREAM BANKS AND BED, AND ENSURE THAT FISH HABITAT IS NOT DREGRADED.

Where in-stream/near-stream structures or major channel modifications cannot be avoided the resulting impacts can be reduced through careful design and installation.

3.2.5 Site Restoration and Monitoring

(1) SITE RESTORATION TO AS NEAR PRECONSTRUCTION CONDITIONS AS POSSIBLE SHOULD BE INITIATED AND COMPLETED AS SOON AS POSSIBLE.

Delays between the completion of construction and site restoration can lead to short and long-term impacts (e.g. slumping of banks resulting from improper stabilization).

(2) WHERE NECESSARY INTERIM EROSION/SEDIMENT CONTROL MEASURES SHOULD BE INSTALLED UNTIL LONG-TERM PROTECTION CAN BE EFFECTIVELY IMPLEMENTED.

Where permanent restoration is not feasible (e.g. seeding outside growing season) the lack of interim measures can complicate long-term restoration by allowing further damage to occur.

(3) THE EFFECTIVENESS OF RESTORATION MEASURES (e.g. bank stabilization) SHOULD BE MONITORED BY THE PROPONENT AND NECESSARY MAINTENANCE SHOULD BE UNDERTAKEN PROMPTLY.

The mitigation of long-term impacts through careful site restoration can only succeed if adequately maintained. This should be considered normal project maintenance.

III MEETING WATER RESOURCES CONTENT REQUIREMENTS DURING ENVIRONMENTAL ASSESSMENT PREPARATION

1. INTRODUCTION

The following chapter outlines the general concerns and suggestions most commonly expressed during review, by MOE staff, of the water resources aspects of EA's. This guide will be especially useful as a time saving reference during the preparation and review of "pre-submission" type EA's.

The first section summarizes suggestions for presentation of information as a preamble to a discussion of baseline data requirements. Next, there is a brief consideration of project description and identification of potential impacts. A discussion regarding the assessment of impact magnitude follows, and the guide concludes with a discussion of content requirements concerning mitigative measures, construction practices, site restoration, and monitoring.

2. PRESENTATION OF INFORMATION

General suggestions regarding the water resources coverage in EA reports, which have been made on numerous occasions, can be summarized as follows:

(1) <u>All summary statements should be substantiated by valid references and/or data.</u>

All secondary sources (technical reports, correspondence, personal communications, etc.) should be identified as such and the appropriate reference(s) should be appended to the EA wherever possible.

An apparent conflict between two sources of information on a particular suject should not be suppressed. If one is favoured the reasons should be presented in a manner which allows the reader to assess the basis on which any judgements were made.

(2) <u>The results of all analyses should be verifiable.</u>

The presentation of numerical results and qualitative estimates cannot be considered adequate unless an outline of how they were obtained (i.e. data sources should be provided, calibration procedures explained, etc.) is appended. This will permit the reader to assess the accuracy of all interpretations or applications (e.g. tables, graphs, etc.).

3. BASELINE DATA REQUIREMENTS

Data on the water environment must provide the reader of the EA with a clear picture of the pre-construction conditions as they pertain to the quality and quantity of ground and surface water. Without this information it will not be possible to identify all the potential impacts of a proposal upon the water environment, and no determination of the magnitude of net impact will be obtainable.

General information describing the entire study area should precede more comprehensive site specific data regarding the preferred site/route. In some cases pertinent information may be derived from the "Biophysical Land Classification" program of Environment Canada.

3.1 Study Area Data

In most cases the study area overview should include information on the following:

- topography
- soil composition and drainage characteristics
- pleistocene stratigraphy
- land use
- ground and surface water resource locations and uses (well locations and depths, stream locations and sizes, recreational areas).

Experience has shown that an extremely useful method of satisfying these requirements is to prepare a series of maps at a scale capable of showing all permanent watercourses (in most cases the 1:20,000, 10 m contour topographic sheets ...available through the Ontario Basic Mapping Program of MNR... will be acceptable). If this approach is adopted these maps should be complemented by descriptive text.

3.2 Preferred Site/Route Data

Detailed, site specific water resources related data will be required on the preferred site/route (i.e. right-of-way, borrow sites, storage yards, etc.) as the basis for identification and estimation of the magnitude of potential impacts on the water environment. This will also assist in the interpretation of results from monitoring during construction and after project completion.

These data can be classified under the headings "surface water" and "ground water".

3.2.1 Surface Water Data

Site specific surface data should include:

a) precipitation records;
b) streamflow records;
c) flow duration and flood frequency curves (constructed from "a" and "b");
d) channel dimensions and geometry (bankfull and low flow width, depth, flow velocity, and slope, sinuosity);
e) local water quality (both upstream and downstream from "site");
f) local water usage (drinking, recreation, industrial, aquatic life);
g) bed material composition (grain size distribution, pool to riffle ratio);
h) near-stream/floodplain soil characteristics (composition, structure, drainage); and
i) local topography (slope, slope length).

This information will provide a good indication of the expected range of flows, the susceptibilty to surface damage and erosion, and the existing water quality and use. In addition to providing the basis for estimating the magnitude of impacts on the surface water, it will supply a description of pre-construction conditions which can be used as a goal for post-construction site restoration.

3.2.2 Ground Water Data

Site specific subsurface data should include:

a) pleistocene stratigraphy (thickness and composition of overburden, bedrock depth);
b) location and description of aquifers;
c) depth to water table levels (local well locations, seepage areas, borehole results);
d) ground water flow estimates (horizontal and vertical flows based on "a", "b" and "c"); and
e) water usage and quality.

This information should provide an understanding of existing ground water conditions upon which subsequent estimates of impact magnitude can be based, a goal for post-construction site restoration and baseline data for construction and post-construction monitoring.

<u>Design details and mitigative measures will depend upon both surface and subsurface information (the importance of these data cannot be overemphasized)</u>.

The focus and presentation of this preferred site/route data will depend upon the nature of the proposed undertaking and the local environment. As with the study area data, however, maps which include topography and drainage can be used advantageously (in this case the suggested scale is 1:2000 with 1 m contours for topographic sheets). Site specific plans and cross sectional drawings are extremely valuable for such items as watercourse crossings or cut and fill activities.

4. DESCRIPTION OF THE PROPOSED UNDERTAKING AND IDENTIFICATION OF POTENTIAL IMPACTS

This section of an E.A., report should provide a level of detail sufficient to provide a clear understanding of project design, location, and types of construction activities, including sequence and timing. This information when evaluated in conjunction with the preferred site/route description will enable a comprehensive list of potential impacts on the water environment to be generated.

This list should incorporate <u>specific</u> aspects of both the project and the environment and does not, therefore, lend itself to a "standard checklist".

5. ESTIMATION OF IMPACT MAGNITUDE

Once the comprehensive list of potential impacts has been compiled an effort should be made to quantify them wherever possible. In many cases this will involve the application of appropriate models, the sophistication of which will depend upon the nature of the proposed undertaking and the sensitivity of the environment (as documented by the baseline data). Examples include estimation of the impacts resulting from: increased runoff (hence increased peak flows and depletion of base flows); increased sediment discharge; increased potential soil loss; increased stream velocity; and lowering of ground water levels.

In certain cases it may be acceptable to compare the proposed undertaking with a similar, previously completed project and estimates of impact magnitude may then be based on the documented impacts of the previous venture. Such an approach, however, requires that the similarities, both in the undertaking and environment, be thoroughly researched and that all differences be clearly presented.

<u>All estimates of impact magnitude, both quantitative and qualitative, should be accompanied by an indication of their precision.</u>

6. MITIGATIVE MEASURES, SITE/ROUTE RESTORATION, AND MONITORING

Having identified and estimated the magnitude of impacts on a site specific basis, the report should outline the strategy for implementation of selected mitigative measures, a site/route restoration plan, and an outline of construction and post-construction monitoring.

As with the identification of potential impacts, the list of mitigative measures offered should be the result of a detailed evaluation of the project design and the site specific environmental data. The estimated magnitude of impacts should also be incorporated to ensure that the resulting commitment to "good housekeeping" construction practices and installation of effective mitigative measures is tailored to the site, not merely a "standard" list.

The report must also provide some commitment by the proponent to: the monitoring and maintenance of all relevant mitigative devices, the provision of a contingency plan for unexpected events, and the rapid implementation of post construction site/route restoration to near baseline conditions or better where possible. Monitoring results are to be compared with baseline data and will indicate the effectiveness of impact mitigation and site/route restoration. An assessment can then be made regarding the need for further action.

The level of detail of this section of the EA document should be commensurate with that of the "preferred site/route data" and "description of the proposed undertaking".

REFERENCES

Canter, L. 1977: Environmental Impact Assessment, McGraw-Hill, New York, 331 pp.

Cummins, K.W. and Spengler, G.L. 1978: Stream Ecosystems, Water Spectrum, Fall, 1-9/

Guy, H.P. 1970: Sediment Problems in Urban Areas, U.S. Geol. Survey Circ. 601-E.

Hynes, H.B.N. 1973: The Effects of Sediment on the Biota in Running Water, Proc. Hydrol. Symp. Univ. of Alberta, 652-663.

Illinois EPA 1979: Water Quality Management Plan, Volume III, Division of Water Pollution Control, Springfield, 384 pp.

Ontario Ministry of the Environment, Water Management Goals, Policies, Objectives and Implementation Procedures. Water Resources Branch, 1978.

Wolman, M.G. and Schick, A.P. 1967: Effects of Construction on Fluvial Sediment in Urban and Suburban Areas of Maryland, Water Resources Research 3(2), 451-464.

BIBLIOGRAPHY

Anttila, P.W. and Tobin, R.L. Fluvial Sediment in Ohio, Geol. Survey Water-Supply Paper 2045. Washington: U.S. Govt. Printing Office, 1978.

Barton, B.A. Effects of Highway Construction on the Limnology of Hanlon Creek, (Guelph), Ontario, Thesis. Guelph: Faculty of Graduate Studies, University of Guelph, 1974.

Caltrans, Analysis of Short and Long Term Effects on Water Quality for Selected Highway Projects. Sacramento, California, 1979.

Chisholm, J.L. and Downs, S.C. Stress and Recovery of Aquatic Organisms as Related to Highway Construction Along Turtle Creek, Geol. Survey Water-Supply Paper 2055. Washington: U.S. Govt. Printing Office, 1978.

Keller, E.A. "Channelization - A Search for a Better Way", Geology, Vol. 3, No. 5, 1975, 246-248.

Keyes, D.L. Land Development and the Natural Environment: Estimating Impacts. Washington: The Urban Institute, 7604.

Mathers, J.S. The Effects of Highway Construction on Galt Creek, Ontario. Ontario Ministry of Natural Resources, Ministry of Transportation and Communication, 1978.

Ontario Ministry of the Environment. Evaluating Construction Activities Impacting on Water Resources. Water Resources Branch, 1976.

Ontario Ministry of Transport and Communications, Highway Construction Practices and Potential Environmental Concerns, 1978.

Schoof, R. "Environmental Impact of Channel Modification", Water Resources Bulletin, Vol. 16, No. 4, August 1980, 697-716.

Schaenman, P.S. Using an Impact Measurement System to Evaluate Land Development. Washington: The Urban Institute, 7609.